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Federal Communications Commission
Office of the Secretary

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FCC MAIL BRANCH

Office of the Secretary
Federal Communications Commission
1919 M Street, NW
Washington, DC 20554

Dear Mr. Secretary:

Kindly find enclosed seventeen (17) copies of the Comments of Richard Jay Solomon in FCC MM Docket No. 87-268 in response to the Notice of Proposed Rule Making of October 24, 1991 on policies and rules for implementing advanced television (ATV) service in the United States.

I would appreciate three copies each being delivered to Chairman Sikes, as well as to Commissioners Barrett, Duggan, Marshall, and Quello. One copy is for the Chief of the Mass Media Bureau, Mr. Roy J. Stewart, Room 314; and one copy for the Chief of the Office of Plans and Policy, Mr. Robert Pepper, Room 822.

Your cooperation is appreciated.

Sincerely,

Richard Jay Solomon

Richard Jay Solomon
By Federal Express

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December 20, 1991

Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of Advanced Television Systems and Their Impact upon the Existing Television Broadcast Service	)))))	MM Docket No. 87-268

Comments of

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(The opinions expressed herein are those of the author's only and do not necessarily represent those of any laboratories or programs at M. I. T.)

1. These comment are directed to Paragraph 47 of the NPRM FCC 91-337, Adopted October 24, 1991.

2. First, I wish to complement the ongoing activities of the FCC's Advisory Committee on Advanced Television Services (ACATS) in studying and making recommendations regarding the implementation of advanced television in the U.S. These comments in no way should be construed as requesting a delay in such activities; if anything, the faster the work of ACATS is concluded without impairing the decision process, the better it will be for the U.S. as a whole.

3. As the Commission is aware, ACATS Planning Subcommittee Working Party 4 (PS/WP4) is studying and making recommendations regarding the relationship of terrestrial advanced television systems to alternative media, applications and standards. PS/WP4 includes representatives of television broadcasting, cable television, program production, motion picture, consumer electronics, computer, telecommunications and imaging industries, including most of the members of the ad hoc Committee on Open High-Resolution Systems (COHRS) re-

ferred to in the NPRM (Para. 47, footnotes 85-88)[1]. PS/WP4 has met monthly since September of this year to make a concentrated study of the convergence of imaging, communications and computing technologies and has directly addressed the issues in Para. 47 of the instant NPRM, especially definitions, architecture, alternative media and applications, value of interoperability, and measures and metrics. I am an active member of this committee.

4. PS/WP4 is in the process of submitting its interim report to the Planning Subcommittee by December 31, 1991, and held its final meeting on December 17 to finish its work for this year. It plans to continue next year to further refine its definitions, initiate a case-by-case analysis of each of the proponent systems suitability for cost-effective, optimum quality interoperation with alternative delivery media and applications, and coordinate work on high-resolution imaging with the Society of Motion Picture and Television Engineers (SMPTE) and other related industry efforts.

5. Without delaying the current process, I respectfully request that the record for this NPRM be kept open to receive the Dec. 31, 1991 Interim Report of PS/WP4 and other subsequent reports that may be timely.

6. In recognition of the necessity of coordinating standards activities in high-definition television and high-resolution imaging, SMPTE, after a series of workshops on the issues in digital video imaging held jointly by the IEEE-USA and the Advanced Television Systems Committee (ATSC), formed two task forces this past spring to study the architectural questions in defining such standards. One Task Force, being co-chaired by Prof. David Staelin of M.I.T. and Col. Will Stackhouse (USAF, Ret.) of Jet Propulsion Laboratories of the California Institute of Technology, has studied in detail the use of a header structure for a video data stream to better enable devices in the video chain to identify imaging standards and structures (called the "Header-Group"). I am an active member of the Header-Group. The other task force, chaired by David Trzcinski of Picturetel Corp., has been studying over-all architectural questions for imaging chains. The interim reports of these two task forces are to be submitted to the SMPTE at the end of this year, and are being referenced in the ACATS PS/WP4 Interim Report noted in para. 5 above. Both committees drew their members from many of the same groups as in PS/WP4, and represent a similar cross-section of U.S. industry. In addition, the Header-Group had participation from a representa-

[1] Selected Issues: Interoperability, Extensibility, Scalability, and Harmonization of HDTV and Related Standards, Comments to the FCC prepared by COHRS (May 7, 1991) (COHRS Letter).

tive of the European Community's HDTV entity and several foreign-based firms working in HDTV.

7. The work of the Header-Group is of particular relevance to interoperability of alternative video media, and, in the opinion of this commentator, will go a long way towards harmonizing relationships among the various media. Therefore, I respectfully request that this NPRM be kept open so that the reports of these two SMPTE task forces can be submitted early next year, after approval of SMPTE.

8. Attached is a paper I delivered at a conference this month in London, England on HDTV which delves deeper into the issues of extensibility, scalability, and interoperability. My paper is based on input and ideas from COHRS, PS/WP4, and the two SMPTE task forces, but my opinions and conclusions are my own. I respectfully request permission to include this paper in the NPRM record.

FUTURE-PROOFING HRI/HDTV STANDARDS

Richard Jay Solomon,
Research Laboratory of Electronics
Massachusetts Institute of Technology

delivered in London, England at HDTV'92,
December 9, 1991

Let's make some reasonable forecasts for imaging and computing for the next century. We can assume as a baseline the general trends of the past decade, so by the year 2005 or shortly afterwards:

• **Computation will be free, and video displays will be computers.** A range of specialized circuits will offer parallel processing and enormous local storage. Memories will be measured in terabytes, processing in the range of billions of instructions per second, and all the electronics will be engraved on the back of a unitary flat panel costing no more than a TV set costs today.[2] Such appliances will be capable of a large amount of video processing; machine intelligence will be capable of interpreting and manipulating video content.

• **Broadband, digital, switched networks may be accessible almost anywhere in the urbanized, industrialized world,** based on fiber optics and highspeed switching nodes. Broadband starts at 100 megabits per second; systems in excess of several gigabits to terabits per second may be serving most office complexes and campus environments. The rest of the world will have broadband "islands" in major capitals and coastal conurbations, with satellites filling the interstices, albeit at lower bandwidths. Broadband transmission, for those lucky enough to have access, will be cheap — perhaps not more expensive than an ordinary voice telephone call — but for others bandwidth may be still be relatively expensive.

• **Each and every flat panel or imaging device will have a direct connection from its processing unit to the broadband interface**, and it probably won't be a wire!

• **Image capture technology will get much cheaper, much smaller, and improve vastly in quality.** A high-resolution color, video camera will be a desirable accessory for most displays — for full-motion as well as static imaging. Full-motion images, at various spatial and temporal resolutions, will be just another add-on to voice conversations and electronic mail.

But technology is the easy part of any forecast. Determining whether technology will be applied and what penetration rate it may have is harder. In general, erroneous forecasting models have come in two varieties: failures of assessment,

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2. We can assume by 1995, 200 MIPS workstations with gigabyte memories and 64 million logic devices per chip. If flat panel HDTV is to come to pass, with 20 million or more active devices engraved per panel, we can imagine the same process used to place the electronics on its back.

and failures of imagination[3]. Failures of assessment occur when one looks backwards and attempts to make simple linear extrapolations. Not only is this error based on insufficient history or misleading cases, but more important is the false belief that such processes are, indeed, linear. Non-linear equations are unsolvable; more important, feedback from externalities generated by the innovative process may 'seed' a random event with totally unpredictable consequences somewhere down the road – the 'chaos' factor.[4] The projections by IBM and such computer pioneers as John von Neumann in the early 1950s of a total world demand for computers of no more than *ten!*, and the ultraconservative extrapolations of the Haloid Corporation in the late 1950s for dry-paper xerographic copying machines based on the demand for carbon paper are such examples.

Failures of imagination are more complex. Here relevant facts are known, but process innovation is ignored. Such "forecasting" lacks the ability to look forward.

One example is the discovery of electromagnetic waves in the 19th Century and the application of vacuum tubes to electronics a few decades later. These two processes led to the growth of entirely unexpected industries such as entertainment television broadcasting and radar; yet no such forecasts emanated from Maxwell, Hertz, or de Forest at the time.

Functionality is not an additive process. Often when you change just one key element, you can change the process – an underpinning of chaos theory. Assessing the past in order to understand what the future may bring requires an uncanny ability to understand which technologies are key, and how today's technology expands to fit tomorrow's applications.

High-resolution systems

We all suffer from lack of imagination to some extent. All we can know about the future is that it will be different; therefore we should take care not to constrain its possibilities because of the limitations of the present.

The International Telecommunication Union's CCIR recently concluded, that "widely diverse applications...embraced by high-resolution systems...[will result] in numerous different requirements with respect to resolution, sampling distribution, dynamic range, colorimetry, image format, temporal rate and aspect ratio, among other attributes....[H]armonization across this diverse range would

3. Loretta Anania & Richard Solomon, "Divining the Demand for a General-Purpose Digital Network," *Telecommunications Magazine*, Dec. 1987.

4. James Gleick, *Chaos: Making a New Science*, Viking, 1987.

be beneficial, and technically feasible...."[5] For imaging systems in the future, a variety of receiver and display devices will likely emerge: [6]

• inexpensive monitors with simple external connections to antenna or cable systems

• devices containing framestores, with multiple and direct access to video and other image data

• sophisticated components, including wall-size displays with integral framestores and digital processors, tuners, audio systems, storage devices, etc.

• large scale projection systems for theatrical exhibition and electronic billboards.

In the future, *multiple* delivery channels will be the prevalent mode even for traditional broadcast television. These already include over-the-air terrestrial spectrum, direct broadcast satellite, broadcast co-axial cable, and various mass storage devices. The next generation of video delivery will span the range from digital pair-gain technologies over conventional wires to switched optical fiber, and include a large variety of mass data storage systems from solid-state to disks and tape.

Open Systems for Imaging and Video

One way the computer community has handled both the unpredictable future, and extensible interconnection among system elements known and unknown is with *open* architecture and open interfaces. Unfortunately, the term "open" is widely used but imprecisely defined because different groups mean different things by the word. From the perspective of the computer industry, open architecture is simply the public specification of an interface. Other industries have long employed similar principles. For example, the broadcast industry has traditionally specified interfaces and made the specifications public, such as NTSC, PAL, and SECAM. However, open architecture takes on a new significance in the context of the rapid and drastic changes we have noted for the underlying electronics, computation, and imaging technologies.

For HRI/HDTV, open architecture implies an organization of system parameters that are *scalable, extensible,* and *interoperable.*

• **Scalability** means that, at a given time, uniform generation, transmission, and display characteristics can support a range of product quality and cost.

5. CCIR IWP 11/9, "The Harmonization of HDTV Standards between Broadcast and Non-broadcast Applications," Tokyo, October 1990.

6. Based on a document submitted this year by the U.S. delegation to the CCIR 11/9 working party on harmonization.

• **Extensibility** means that, in the future, technological advances can be incorporated without obsoleting existing components and infrastructure.

• **Interoperability** means that sharing digital information is optimized among media, carrier, and equipment technologies and services.

A scalable and extensible system permits future augmentation of system features and functions to embrace unforeseen applications and opportunities. Image representation must allow for the invention of new capture technologies, author and copyright information, copy-protection codes, nonlinearity correction factors, compression and transformation algorithms, etc. Such data can be incorporated via a header associated with each frame or imaging field. SMPTE has formed a task force to design such a header structure as part of an effort for an over-all imaging architecture description. Its report is due at the end of this year.

It is taken for granted, even expected, that many products can be used within some broader context of similar products, no matter the manufacturer. For example, improved photographic films work in existing cameras; a new telephone with enhanced features works with other telephones across a telecommunications network; a Group 3 fax machine can send to and receive from any other Group 2 or 3 fax machine; a new television receiver is expected to display terrestrial broadcast as well as cable programs. Choice among competing products is on the basis of cost, features, and performance.

An open, scalable, and extensible high resolution systems architecture ensures benefits across industries and applications; but this result can be achieved only if approached directly.

Open architecture approaches have found widespread use over the past ten years. The seminal example is the Open Systems Interconnection (OSI) model, adopted by the International Organization for Standardization (ISO), the CCITT, and referenced in a number of CCIR documents[7]. The OSI model specifies an environment where information is exchanged using protocols following a particular pattern of layered interfaces between different functions of a process, from the basic physical interface and the instructions for moving bits over a transmission channel, to the method of processing these bits as information and presenting the final application to a human. While this model was specifically designed for computer process and network interfaces, and cannot be directly mapped to video or imaging systems without distortion, its basic layering principles are applicable for imaging architectures.

Open standards approaches have very successfully been applied to messaging, electronic data interchange, and document architectures. Managed Information Object (MIO) models are being used to share information among open networks and applications which have specific relevance to indexed high-resolution video file structures, compression and coding algorithms, and other imaging header data. Open architecture approaches have also become popular among

7. ISO 7498 and CCITT X.200.

telecommunication regulatory communities worldwide to facilitate network interconnection and reduce barriers to entry for new telecom entities.

Architectural concepts may permit video extensibility beyond that of mere compatibility with future technologies. For example, multiple tight and wide shots of events could be delivered simultaneously over a single channel with sufficient header data in each frame. A large, wide display may present a wide shot while a tight shot may be reserved for a small, narrow-aspect display — both of the same scene. And display systems need not serve just entertainment or recreational purposes; a videophone call from a child away from home may be displayed in a window on a wall-size screen. The header structure need not be complex, nor use more than a tiny fraction of the frame "payload" data. Indeed, the SMPTE task force took this as a directive, and has come out with an extremely compact header which itself will be extensible to point to additional descriptors only when necessary.

Detailing standards for HDTV/HRI

To achieve an open architecture, it is necessary to define the enabling characteristics and parameters, but not specify parameters so as to restrict future applications yet unknown. Open, and evolutionary multi-media, high-resolution imaging systems will have to define the following minimal features:

• **Inherent Data Compression.** The format should be usable with variable data rates in systems and hierarchies of systems where different numbers of bits are allocated to each component of the representation, depending upon storage and transmission channel constraints.

• **Variable Spatial and Temporal Resolution.** Image representation must allow ready and simple transcoding between diverse display systems and a broad variety of input systems with minimal computation and storage on the receiving end.

• **Interconnection.** A HRI/HDTV format should anticipate television transmission and production in computer networked systems, carriage on switched broadband digital and analog fiber optic and coaxial-cable networks, as well as conventional broadcasting modes.

• **Error Tolerance/Graceful Degradation.** An HRI format should anticipate imperfect channels and media and allow for allocation of error correction codes differentially to more or less significant components of the signal. For television broadcasting over imperfect channels, uncorrected errors should have a minimal effect on picture quality for the maximum target audience.

The technology advances expected in the near future have altered the criteria and applicability underlying imaging standards. Before the widespread use of logic processors and inexpensive microelectronics, the definition process for video concentrated on specifying a few numerical system and signal parameters. Now, it is incumbent to consider the system organization and content in a context that recognizes the full importance of the standards and synergies obtained from collateral uses.

The needs of both broadcast and non-broadcast HRI are best met by multiple compatible options within the framework of a standard. For example, 24 fps film can take advantage of a higher resolution at a given data rate than can higher temporal rate imagery which is required for sports broadcast. Electronic News Gathering can often accept lower temporal and resolution quality in order to allow lightweight, and sensitive portable cameras. Ignoring this inherent difference is fundamentally wasteful of both signal quality and bandwidth. It is interesting to note that all of the proponents in the U.S. HDTV contest have proposed flexible methods of trading off spatial, temporal, and areal information depending on the source material and channel characteristics. For example, 24 fps film need not be temporally transcoded before entering a system, but could utilize the maximum data rate of the least flexible part of the transmission, the terrestrial channel, with further processing at the receiver to be displayed at whatever frame rate is best to minimize flicker.

Standardization as a Natural Process

Before the advent of stored-program logic, standards evolved that were primarily dimensional in scope — track gauge, Baudot telegraph start-and-stop bits, voltage and current levels, synchronization signals. A minor change, and system elements would not interwork. In nature, minor evolutionary changes within a species tend to be regressive and often an individual organism may fail to survive or evolve further; species that do survive appear to overcome entropy — that is, they contain negative entropy, which is "information," as defined in communications theory.

In our discussion of open architecture for HRI/HDTV standards-making, we suggest subsuming dimensionality within layers that imply compatibility and extensibility, and, in an analogy to nature, creating typologies which permit disappearance of species (i.e., specific hardware or application software) without disturbing the system equilibrium. This would encourage the implementation of new technologies to increase efficiency and increase diversity (in nature, to aid in survivability) rather than enshrine vested industries.

Defining HRI standards to include chaotic, non-linear factors will not be easy. We will have to learn to think in terms of functional components — using software to download new functions instead of re-wiring a system from scratch, for example. Fortunately, stored-program machines make that possible.

Richard Jay Solomon